CONCEPTUALLY SOUND AND OPERATIONAL METHODS FOR ENVIRONMENTAL VALUATION

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INTRODUCTION

The purpose of this paper is to describe how environmental benefits can be quantified within the context of the current 1983 Principles and Guidelines used by federal water resources agencies to do benefit-cost analysis. The relevant concepts are reviewed and selected results are presented of an earlier effort to develop such guidelines for the St. Johns River Water Management District in Florida (Heaney et al. 1989, Heaney et al. 1991). The interested reader is referred to these two reports for the details of the development of the theory and the extensive case study applications. In addition to summarizing this directly related work, an analysis on how to develop such an environmental valuation methodology is presented. The opinion of this author on this subject has been influenced by participation in an on-going review of Corps of Engineers environmental restoration studies. Also, recent renewed interest in both benefit-cost analysis (U.S. Advisory Commission on Intergovernmental Relations 1993) and better integration of environmental values (Interagency Floodplain Management Review Committee 1994) have generated additional enthusiasm for pursuing these topics.

The balance of this paper is divided into summary discussion regarding the availability of general guidelines for doing benefit-cost analysis including environmental valuation. Then, the Florida case studies are presented. The importance of databases for benefit-cost analysis is stressed. Furthermore, the proposed property valuation approach is described wherein "property" includes lakes, rivers, estuaries, and wetlands. Last, the summary and conclusions are presented.

ADEQUACY OF PRINCIPLES AND GUIDELINES CONCEPTS

The use of benefit-cost analysis techniques for evaluating federal water projects began in 1936. The first interagency guidelines were published in 1950 and have been updated several times. In the 1970s, environmental and social impacts, multiple objective analysis, and risk analysis were added as components of the evaluation process. The 1983 Principles and Guidelines (P&G) revised the procedure to again focus on National Economic Development (NED) as the primary objective (U.S. Water Resources Council 1983). The general theory and numerous applications of benefit-cost analysis are well documented. Schmid (1989) presents a comprehensive review of the field. In addition, the Institute for Water Resources of the Corps of Engineers has prepared more detailed interpretations of how to conduct specific types of benefit-cost analyses. The most recent P&G (1983) present specific instructions for the following categories of water resources:

No.	Category
1.	Municipal and industrial water supply benefits
2.	Agricultural floods, erosion, and sedimentation
3.	Agricultural drainage
4.	Agricultural irrigation
5.	Urban flood damage reduction
6.	Hydropower
7.	Navigation
8.	Recreation
9.	Commercial fishing
10.	Environmental quality

The Environmental Protection Agency is not covered by the Principles and Guidelines. However, for the Florida study, environmental quality was added as the tenth category.

GENERAL GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT

Hufschmidt et al. (1983) classify benefit-cost valuation techniques for assessing effects on environmental quality as shown in Table 1. Their taxonomy partitions valuation techniques into market oriented and service oriented. Examples of applications to producer goods and services and consumer goods and services are included. Ortolano (1984) summarizes the environmental impact methodology using the materials budget approach espoused by Resources for the Future (Kneese and Bower 1979).

They list six ways of controlling unwanted residuals from economic activities.

1. Treat the residual.
2. Reduce the level of output.
3. Produce the same outputs using less damaging production processes.
4. Produce the same outputs using less damaging inputs.
5. Produce different outputs and thereby generate less damaging residuals.
6. Increase materials recovery and reuse, i.e., recycling.

These six methods can be cross-referenced with Table 1.

TABLE 1
CLASSIFICATION OF COST AND BENEFIT VALUATION TECHNIQUES FOR ASSESSING EFFECTS ON ENVIRONMENTAL QUALITY

Valuation Technique	Examples of Application	
	Producer Goods and Services	**Consumer Goods and Services**
Market Oriented		
1. Benefit valuation using actual market prices of productive goods and services		
(a) Changes in value of output	Loss of value of agricultural crops caused by higher salinity	
(b) Loss of earnings	Value of productive services lost through increased illness and death caused by air pollution	
2. Cost valuation using actual market prices of environmental protection inputs		
(a) Preventive expenditures	Cost of environmental safeguards in project design	Cost of noise insulation: Cost of intake water treatment
(b) Replacement cost	Cost of replacing structures damaged by acid rain	Cost of additional painting of houses damaged by air pollution
(c) Shadow project	Cost of restoring commercial fresh-water fisheries damaged by discharge	Cost of supplying alternative recreational facilities destroyed by development project
(d) Cost-effectiveness analysis	Cost of alternative means of disposing of wastewater from a geothermal energy project	
3. Benefit evaluation using surrogate markets		
(a) Marketed goods as environmental surrogates	Cost of sewage treatment processes as proxy for water purification by ecosystems	Price paid for visits to private parks & entertainment as proxy for value of visits to wilderness area
(b) Property value approach	Changes in commercial property values as a result of water pollution	Changes in residential property values as a result of air pollution
(c) Other land value approaches		Prices paid by government for land reserved for national parks
(d) Travel Cost		Valuation of recreational benefits of a public park
(e) Wage differential approach		Estimation of the willingness of workers to trade off wages for improvement
(f) Acceptance of compensation	Compensation for damage to crops	Compensation for adverse health effects
Survey Oriented (hypothetical valuation)		
1. Direct questioning of willingness to pay		
(a) Bidding games		Estimate of willingness to pay for access to an urban park
2. Direct questioning of choices of quantities		
(a) Costless choice method		Hypothetical application to air pollution

Reference. Hufschmidt et al. (1983)

Heaney (1988) reviewed 20 years of efforts to define the benefits of urban stormwater quality management. He concluded that it is essential to quantify impacts in terms of benefit-cost analysis. It is difficult, if not impossible, to develop meaningful measures of ill-defined concepts, such as ecosystem health or fishable and swimmable waters.

The concepts from environmental economics are clear. The technological externalities associated with productive activities should be incorporated into benefit-cost calculations. Ideally, these impacts should be internalized so as to not cause detrimental off-site impacts using one or more of the six options listed above. Numerous applications of these principles have been made in the water resources field. For example, new urban flood control and drainage systems must be designed so as to not increase the peak rate of discharge or the volume of discharge beyond what occurred prior to development. Also, on-site detention systems should provide adequate treatment of the urban runoff so as to not degrade downstream water quality.

Thus, the general concepts of benefit-cost analysis, including environmental economics, appear to provide adequate guidelines for how to properly account for environmental impacts. However, the application of these concepts has not been consistent in the water resources field. Many of the existing projects were evaluated and constructed prior to the 1960s and 1970s when the key environmental economics principles were articulated. However, we still see major problems in incorporating these principles in contemporary benefit-cost analysis for reasons to be discussed in the following sections.

The next section summarizes the results of a three year effort to develop a more complete and consistent methodology for doing benefit-cost analysis that incorporates environmental impacts. The research was done for the St. Johns River Water Management District (SJRWMD) who was seeking a better way to prioritize its watershed management activities. A significant part of the SJRWMD contains Corps of Engineers projects built prior to 1970.

FLORIDA CASE STUDIES

The purpose of this section is to present an overview of a three year effort, conducted from 1988 to 1991, to develop a benefit-cost methodology suitable for a regional water management agency in northeast Florida (Heaney et al. 1989 and Heaney et al. 1991). The history of the development of the Corps of Engineers project in this area and the current water control manual are presented in Vearil (1991). The St. Johns River Water Management District (SJRWMD) wanted a benefit-cost methodology developed to assist it in evaluating alternative water resources planning and operations proposals. The SJRWMD is the operating agency for several Corps of Engineers projects located in its region. A map of the SJRWMD is shown in Figure 1. Thus, we had the benefit of being able to review earlier benefit-cost estimates for some components of the case study. However, in this study, we were not constrained to follow the P&G, but rather were able to use the P&G to the extent we felt it was an appropriate guideline. Environmental valuation was a very important part of the study because of on-going environmental restoration and land acquisition programs.

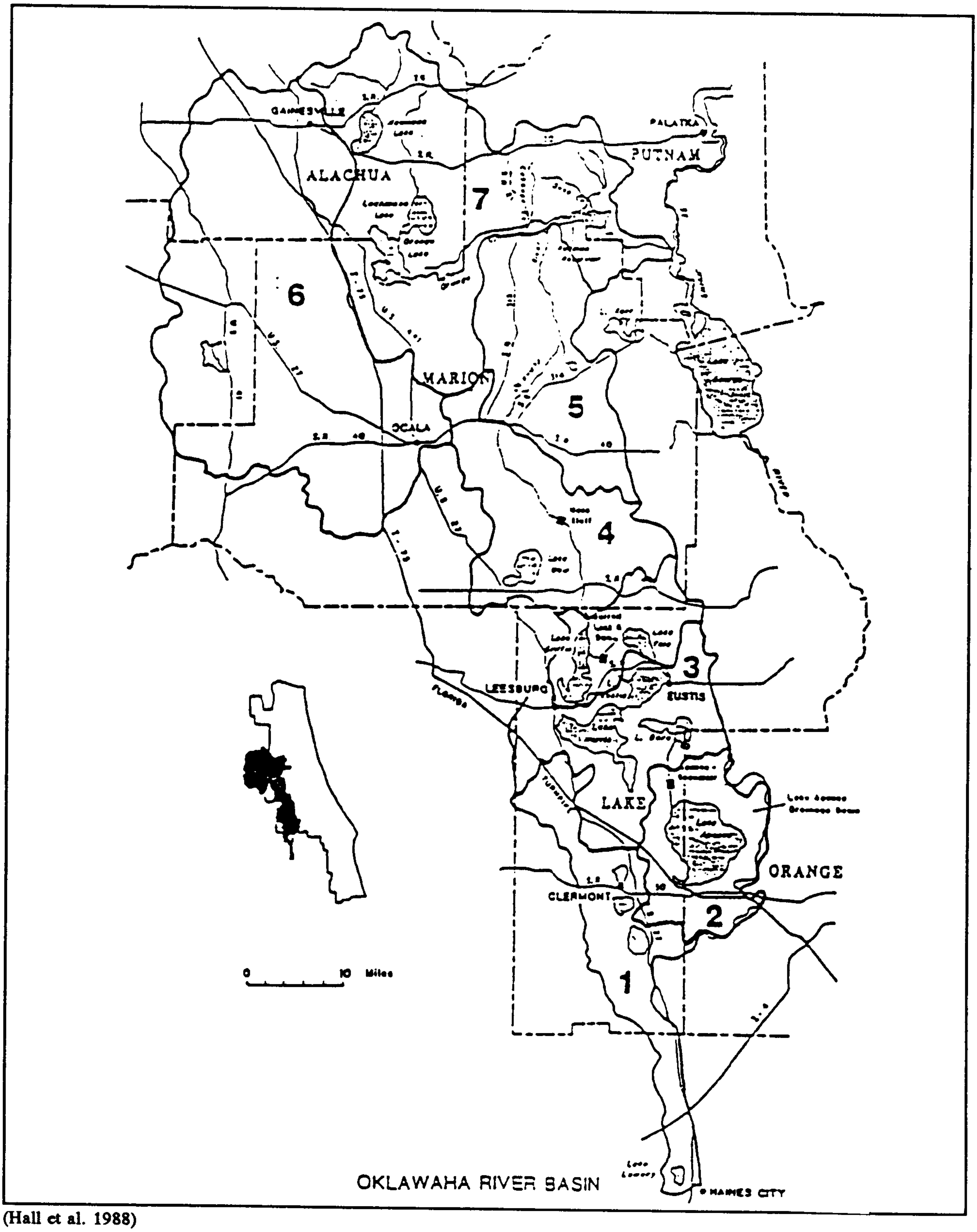
The study area for the Florida socio-economic analysis is the Upper Oklawaha River Basin located in central Florida as shown in sub-basins 1, 2, and 3 of Figure 1. The focal point of the initial study (Heaney et al. 1989) was the environmental impact of the muck farming activities at the north end of Lake Apopka on the lake itself and on downstream water quality. The muck farms were created by placing a levee across the north end of Lake Apopka in order to permit farming of the rich muck soil as shown in Figure 2. After many unsuccessful efforts to protect this low lying muck land, an adequate system was finally installed in the early 1940s. While the agricultural productivity of the muck farms is quite high, the environmental costs to Lake Apopka have also been high. Within a few years of pumping large amounts of agricultural drainage water into Lake Apopka, it became eutrophic and its recreational use declined precipitously. Lake Apopka is now the subject of a $50 million cleanup sponsored by the State of Florida. The Lake Apopka case study is a smaller version of a similar project in south Florida wherein over 600,000 acres of agricultural land was drained by constructing a dike along the south end of Lake Okeechobee. The backpumping of this drainage water into Lake Okeechobee is a threat to the primary water supply source for south Florida and the discharge of drainage water to the south poses a threat to the Everglades.

During the second phase of the study, we looked at the downstream lakes in the Upper Oklawaha chain with particular emphasis on Lakes Harris and Griffin (Heaney et al. 1991). This study area is part of the Corps of Engineers Four River Basin project (Vearil 1991). Detailed recreation benefit evaluations were performed. We also looked at the expected benefits from public acquisition of thirteen candidate parcels of land in the Upper Oklawaha Basin as shown in Figure 3. This evaluation was done in cooperation with the land acquisition group at the SJRWMD. They had independently developed their own method for prioritizing land acquisition. Finally, we analyzed two adjacent lakes located about 50 miles north of the Upper Oklawaha Chain. Lakes Brooklyn and Santa Fe illustrated the importance of lake level fluctuation on land values.

Results from these case studies are presented below within the context of developing methods for overall environmental valuation.

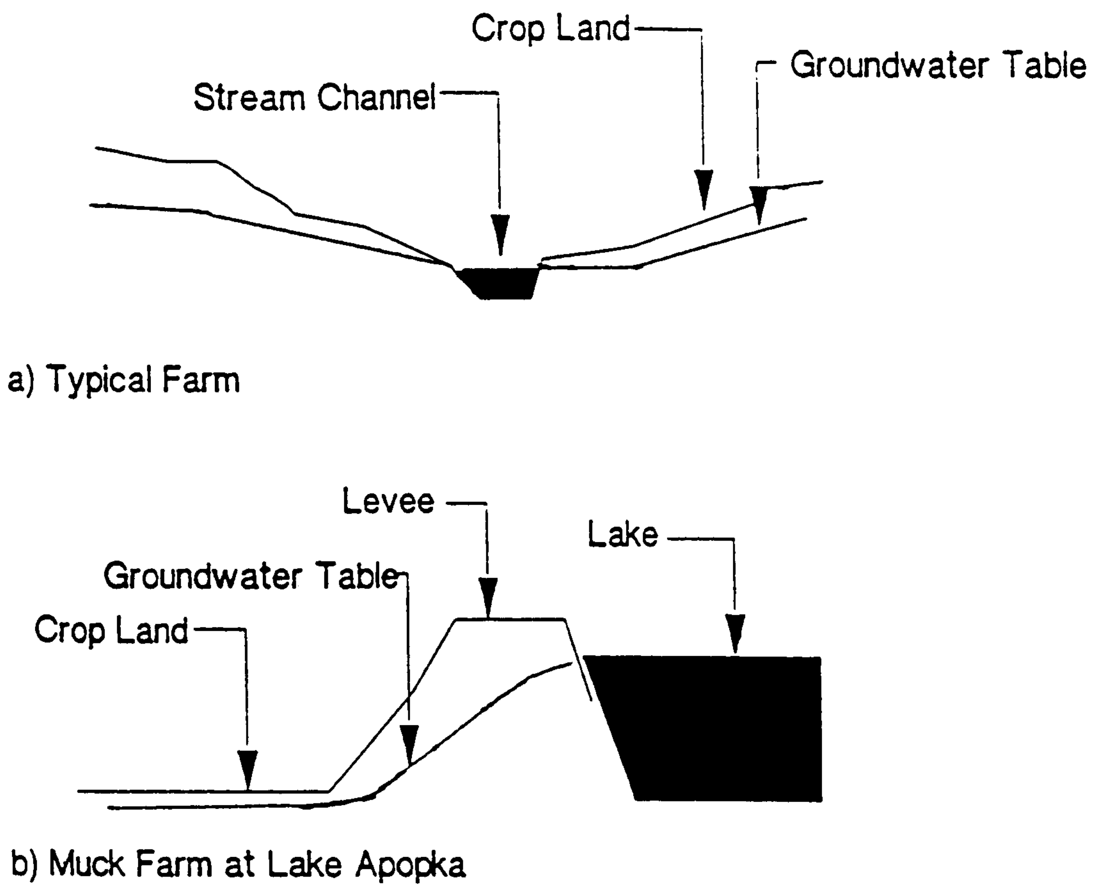
DATABASES FOR BENEFIT-COST ANALYSIS

In the 58-year history of doing benefit-cost analysis, the primary emphasis has been to develop conceptually sound methodologies and normative models for water resources planning of new investments. Unfortunately, virtually no work has been done on retrospective evaluations of the actual realizations of benefits and costs. Without such feedback mechanisms, we do not have reliable databases for



(Hall et al. 1988)

FIGURE 1
MAP OF THE OKLAWAHA RIVER BASIN AND BOUNDARIES OF THE UPPER ST. JOHNS RIVER WATER MANAGEMENT DISTRICT



(Heaney et al. 1989)

FIGURE 2
ILLUSTRATION OF HYPOTHETICAL CONDITIONS AT LAKE APOPKA MUCK FAMRS, AND TYPICAL FARMING AREAS

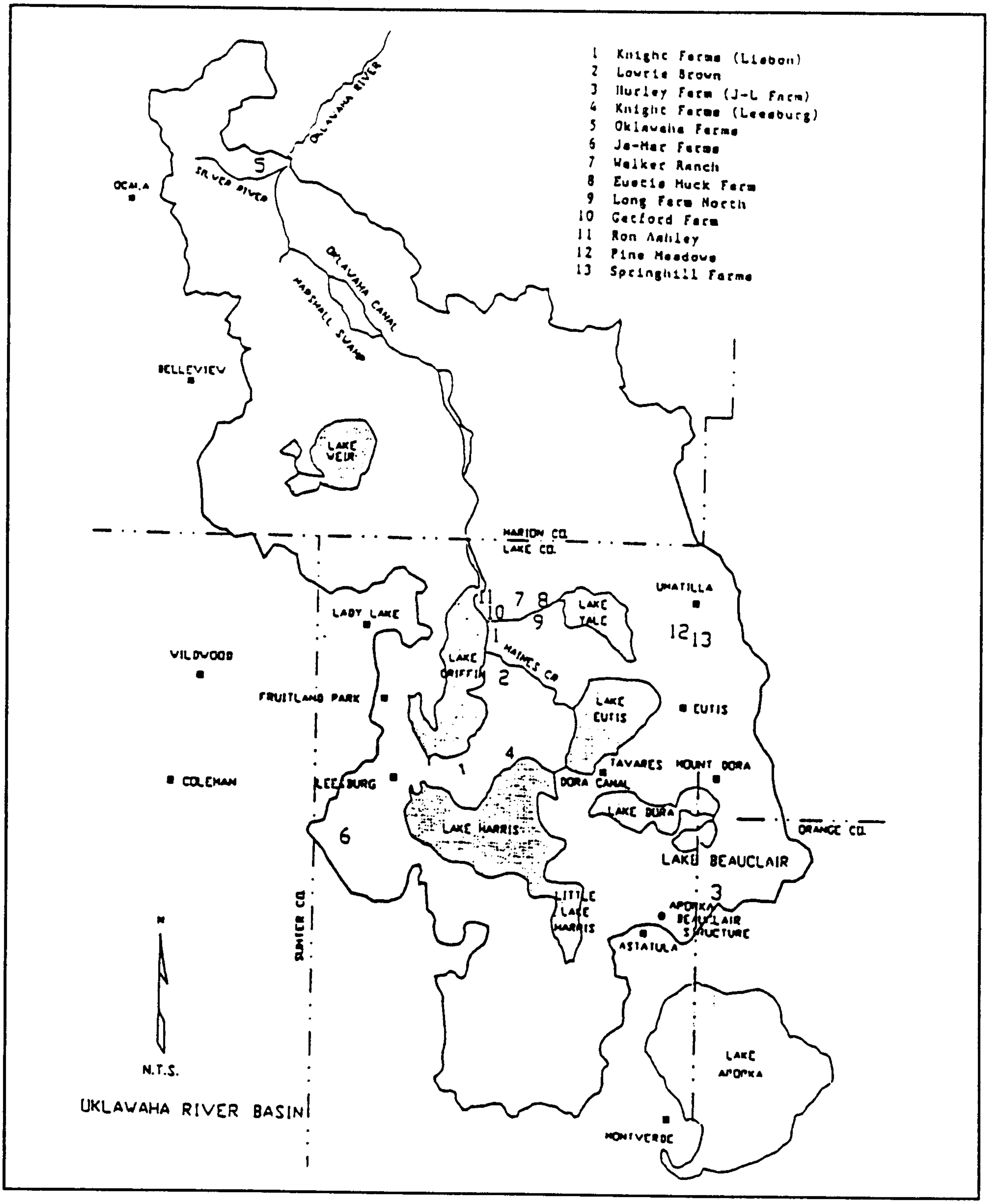


FIGURE 3
LOCATION OF PROPERTIES BEING CONSIDERED FOR ACQUISITION

doing benefit-cost analysis. The primary focus of contemporary water management activities in the United States is on operations management. Consequently, we find ourselves ill-prepared to develop meaningful estimates of benefits based on the almost total lack of systematically developed databases over the past 58 years. The unfortunate result of the predilection with models and concepts is that benefit-cost information is viewed with great skepticism by other professionals due to its weak database. Indeed, the lack of attention to developing meaningful databases for doing benefit-cost analysis stands in stark contrast to other environmental sciences which develop reliable field data before postulating elaborate normative theories.

This lack of reliable socio-economic information became apparent early in our Florida studies (Heaney et al. 1989, Heaney et al. 1991). Fortunately, we discovered the availability of county and state tax assessor's information late in the effort. Tax assessors are responsible for valuing property for all use categories as the basis for assessing ad valorem taxes. Because of the importance of these estimates, standardized procedures have been developed. Of paramount importance is the fact that the database for doing these assessments is available and being updated continuously. For example, the State of Florida divides land uses into 100 categories. These 100 categories are further partitioned so that 459 sub-codes exist. The State of Florida Department of Revenue also has a standard method of calculating the value in use for all agricultural activities in the state. These crop income estimates are calibrated against land sales data to get reliable estimates of value in use. An example of this system is shown in Table 2. The effect of environmental influences can be estimated based on the expected value of various levels of land "improvements" which correlate directly with the extent of available irrigation water and adequate drainage.

PROPERTY VALUE AS CAPITALIZED EQUIVALENT OF FUTURE EARNINGS

The effect of environmental enhancement or degradation on property values has been studied by numerous researchers for air and water management systems. A major advantage of using property values as a measure of environmental quality is that databases are available through property transactions as discussed above. Economists refer to this approach as hedonic valuation.

Freeman (1979) provides an excellent summary of efforts to relate urban property values to air quality. The general conclusion of nearly all of these studies was that air quality is capitalized in property values but empirical relationships varied greatly as did the actual variables included in the studies. Tobin and Newton (1986) examined the impact of flood hazard on property values. The magnitude and frequency of flooding along with the socio-economic characteristics of the residents in the floodplain were found to affect the rate of recovery of land values following a flood event. Heaney et al. (1989, 1991) used a more process-oriented approach coupled with hydrologic and water quality models to estimate the impact of environmental quality on property values. The results of this effort and associated case studies are presented below:

Real estate appraisers estimate market value which can be defined as (Boyce 1981):

> "The highest price in terms of money which a property will bring in a competitive and open market under all conditions requisite to a fair sale, to the buyer and seller each acting prudently, knowledgeably, and assuming the price is not affected by undue stimulus."

The present value of a series of future annual income is:

$$PV = I_1/(1+i) + I_2/(1+i)^2 + \dots + I_n/(1+i)^n$$

where

PV	=	present value, \$
I_t	=	annual earnings in year t
n	=	number of years
i	=	discount rate

If $I_1 = I_2 = \dots = I_n$ then equation 1 can be expressed as:

$$PV = I\,[\,1 - (1+i)^{-n}\,]/i$$

As *n* tends to infinity, the present value becomes:

$$PVC = I\,/\,i$$

where

PVC	=	capitalized present value of an infinite stream of annual future benefits
I	=	expected annual earnings
i	=	discount rate

The present value, PVC, is called the capitalized value of the future income stream.

The value of the land is enhanced by provision of improved water management such as irrigation and drainage. However, if this development causes technological externalities and the land owner is responsible for mitigating these damages, then the net land capitalized land value is:

$$PVCN = (\,I - C\,)\,/\,i$$

where

PVCN	=	capitalized present value with externalities internalized
C	=	internalized control costs to mitigate the external effects

For example, a detailed investigation of the rate of return for the muck farms north of Lake Apopka revealed an

TABLE 2
EXAMPLE OF STATE OF FLORIDA CROP DATABASE

				Costs, $/acre Manage			Trees/acre = 116 Service life = 30						
							Net Income Due To		Capitalization Rate		Value Per Acre		
Effective Age, Yr.	Yield Boxes/ Acre	Price $/Box	Gross Income, $	5% of Gross	Production Cost	Net Income	Land	Trees	Land	Trees	Land	Trees	Total
4	151	6.30	951	48	667	237	153	84	0.1277	0.1661	1198	504	1702
6	180	6.30	1134	57	667	410	153	257	0.1277	0.1693	1198	1520	2718
8	209	6.30	1317	66	667	584	153	431	0.1277	0.1731	1198	2489	3687
10	238	6.30	1499	75	667	757	153	604	0.1277	0.1777	1198	3401	4600
12	273	6.30	1720	86	667	967	153	814	0.1277	0.1832	1198	4443	5641
14	307	6.30	1934	97	667	1170	153	1017	0.1277	0.1902	1198	5349	6547
16	342	6.30	2155	108	667	1380	153	1227	0.1277	0.1991	1198	6162	7360
18	383	6.30	2413	121	667	1625	153	1472	0.1277	0.2110	1198	6978	8176
20	429	6.30	2703	135	667	1901	153	1748	0.1277	0.2277	1198	7675	8873
22	464	6.30	2923	146	667	2110	153	1957	0.1277	0.2527	1198	7745	8943
24	464	6.30	2923	146	667	2110	153	1957	0.1277	0.2943	1198	6650	7848
26	464	6.30	2923	146	667	2110	153	1957	0.1277	0.3777	1198	5181	6380
28	464	6.30	2923	146	667	2110	153	1957	0.1277	0.6277	1198	3118	4316
29	464	6.30	2923	146	667	2110	153	1957	0.1277	1.1277	1198	1735	2934

Reference. State of Florida Dept. of Revenue, 1991.
(Heaney et al. 1991)

TABLE 2 (Continued)
EXAMPLE OF STATE OF FLORIDA CROP DATABASE

Example 2. Pastureland Schedule -- Central/Southern

Type	Quality	Animal Unit Months		Acres/Animal		Market lbs/acre	Price $/lb	Gross Income, $	Operating Expenses, $	Management, 5% of gross Income, $	Net Income, $	Capitaliz Rate	Land Value, $
		Range	Typical Value	Range	Typical Value								
Improved	Poor	<=6	6	--	--	153	0.611	93.48	68	4.67	20.81	0.1275	163.21
	Average	7-9	8	--	--	204	0.611	124.64	91	6.23	27.41	0.1275	214.99
	Good	10-12	10	--	--	255	0.611	155.81	108	7.79	40.01	0.1275	313.84
	Excellent	>12	13	--	--	331	0.611	202.24	125	10.11	67.13	0.1275	526.50
Semi-Improved	Poor	--	--	>=5	5	56	0.611	34.22	22.1	1.71	10.41	0.1275	81.61
	Good	--	--	3-4	3.5	79	0.611	48.27	31.2	2.41	14.66	0.1275	114.95
	Excellent	--	--	<3	2.7	103	0.611	62.93	40.4	3.15	19.39	0.1275	152.05
Native/ range	Poor	--	--	>15	15	14.8	0.611	9.04	4.2	0.45	4.39	0.1275	34.44
	Good	--	--	9-14	12	18.5	0.611	11.30	5.2	0.57	5.54	0.1275	43.44
	Excellent	--	--	<=8	7	31.5	0.611	19.25	8.9	0.96	9.38	0.1275	73.60

expected annual return of about $460 per acre (Heaney et al. 1989). Using a discount rate of 10 percent, the expected value of this land would be $4,600 per acre. Detailed studies of comparable muck land indicated an average selling price of $4,500 per acre, very close to farm budget estimate. The data requirements for the farm budget analysis are very high. Thus, the land sales estimates are the preferred way to make these estimates. For the case of Lake Apopka, the estimated cleanup costs are $50,000,000. The equivalent annual cost is about $5,000,000 per year. If the owners of the 14,000 acres of muck land had to pay this cost, then their control cost, C, would be about $360 per acre per year. Then, the expected value of this land would be reduced to about $1,000. The unresolved policy issue for Lake Apopka, the Everglades Agricultural Area, and for other agricultural areas is twofold: what level of control is needed, and who should pay this cost? For Florida conditions, about 5-15 percent of the land needs to be set aside to serve as equalizing storage and to provide water quality control on-site in order to internalize this problem. Depending on how the public policy debate turns out, the land values will range from unaffected to greatly reduced.

Detailed estimates were made of the loss in recreation value due to a degraded Lake Apopka (Heaney et al. 1989). The annual losses in recreation values were estimated to increase from $3.3 million per year in 1990 to $5.1 million per year by the year 2020. These losses are of the same magnitude as the present value of the farming activity near Lake Apopka. In this study, the relative economics are shifting in favor of remediation due to the rapid increases in population in the area. A summary of the overall balance sheet for the decades from 1960 to 2020 is shown in Table 3. As the affected population increases from 321,000 in 1960 to nearly 1.3 million in the year 2020, the net benefits of the muck farm activity go from positive to negative by the late 1980s.

This Lake Apopka case study is representative of the large, unresolved problem of agricultural land development in the United States. A closed system approach, as recommended in the Kesterson case study of agricultural drainage problems in California, would be even morerestrictive and expensive (San Joaquin Valley Drainage Program 1990). The specific recommendations for the Kesterson case are:

- Source control. On-farm improvements in the application of irrigation water to reduce the source of deep percolation in order to reduce the quantity of drainage water.

- Drainage reuse. Reuse drainage water on progressively more salt-tolerant plants.

- Evaporation system. Store and evaporate drainage water after reuse on salt-tolerant crops.

- Land retirement. Cease irrigation of more problem prone areas.

- Ground water management.

- Discharge to San Joaquin River where water quality standards can be met.

Institutional change including tiered water pricing, improved scheduling, water transfers and marketing, and formation of regional drainage management organizations.

Land irrigation and drainage of wetlands for agriculture has been a major government policy for well over a century. However, if one internalizes the detrimental effects of these activities, then the economics can shift considerably. The relative merits of remedial actions need to be evaluated on a case-by-case basis. Referring to the Lake Apopka example, the economic value of the crops is high, but so are the detrimental impacts. In this study area, the affected lake is near a rapidly urbanizing area (Orlando) with changing attitudes towards environmental quality. The people have shown a demonstrated willingness to control this pollution problem.

The recommended method for valuing environmental impacts is to use the tax assessor's database coupled with hydrologic information on the extent of water management to estimate property value impacts. This will account for the benefits to riparian and nearby lands. The value of rivers, lakes, wetlands, and estuaries can be estimated as a function of the services provided by these water bodies. Detailed descriptions for lakes and wetlands are presented later in this paper. For example, the Florida Department of Revenue has 38 categories of pasture land productivity ranging from poor to excellent. Much of the variation in quality is due to water management. The expected value of this land as it is affected by water management of wet and dry conditions can be estimated using Figure 4. This method is completely compatible with the Corps of Engineers' risk assessment methodology (Greeley-Polhemus Group 1992). The extent of "improvements" can be related directly to the ability to control water levels. However, the more sophisticated water management systems reduce on-site surface and subsurface soil moisture storage. Thus, the amount of irrigation and drainage water increases as the land is "improved" causing increased off-site externalities.

The results of a survey of the sales prices of muck land in Florida, shown in Table 4, indicate that these land values range from a minimum of about $300 per acre for unimproved muckland to over $5,000 per acre for vegetable crops with sophisticated water management. The market sales approach is much easier to use than the farm income approach and is the recommended method for riparian and nearby lands. The next sections describe procedures for estimating an "equivalent" property value for lakes and wetlands based on the functions they perform.

TABLE 3
SUMMARIES OF SOCIO-ECONOMIC GAINS AND LOSSES ASSOCIATED WITH LAKE APOPKA, 1860-2020

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		All Values in $1,000/yr. in 1989 $					
			Disbenefits				
Year	Population 1,000's	Benefits Muck Farms	Direct Recreation	General Public	Riparian Property	Total Disbenefits	Net Benefits
1960	321	6400	1136	802	203	2141	4259
1970	414	6400	1464	2068	203	3735	2665
1980	576	6400	2038	2879	203	5120	1280
1990	816	6400	3003	4080	203	7286	(886)
2000	1009	6400	3713	5045	203	8961	(2561)
2010	1135	6400	4177	5675	203	10055	(3655)
2020	1259	6400	4633	6295	203	11131	(4731)

(1) Census year
(2) Census and median projected population for Lake and Orange counties
(3) Estimated net revenue from farming based on ADAM model
(4) Net loss in boating and swimming recreation based on actual and potential use rates
(5) Net loss in value to general public based on their willingness to pay to restore Lake Apopka
(6) Net loss in waterfront property values due to degraded lake
(7) Sum of columns—(4) + (5) + (6)
(8) Column (3) - column (7)

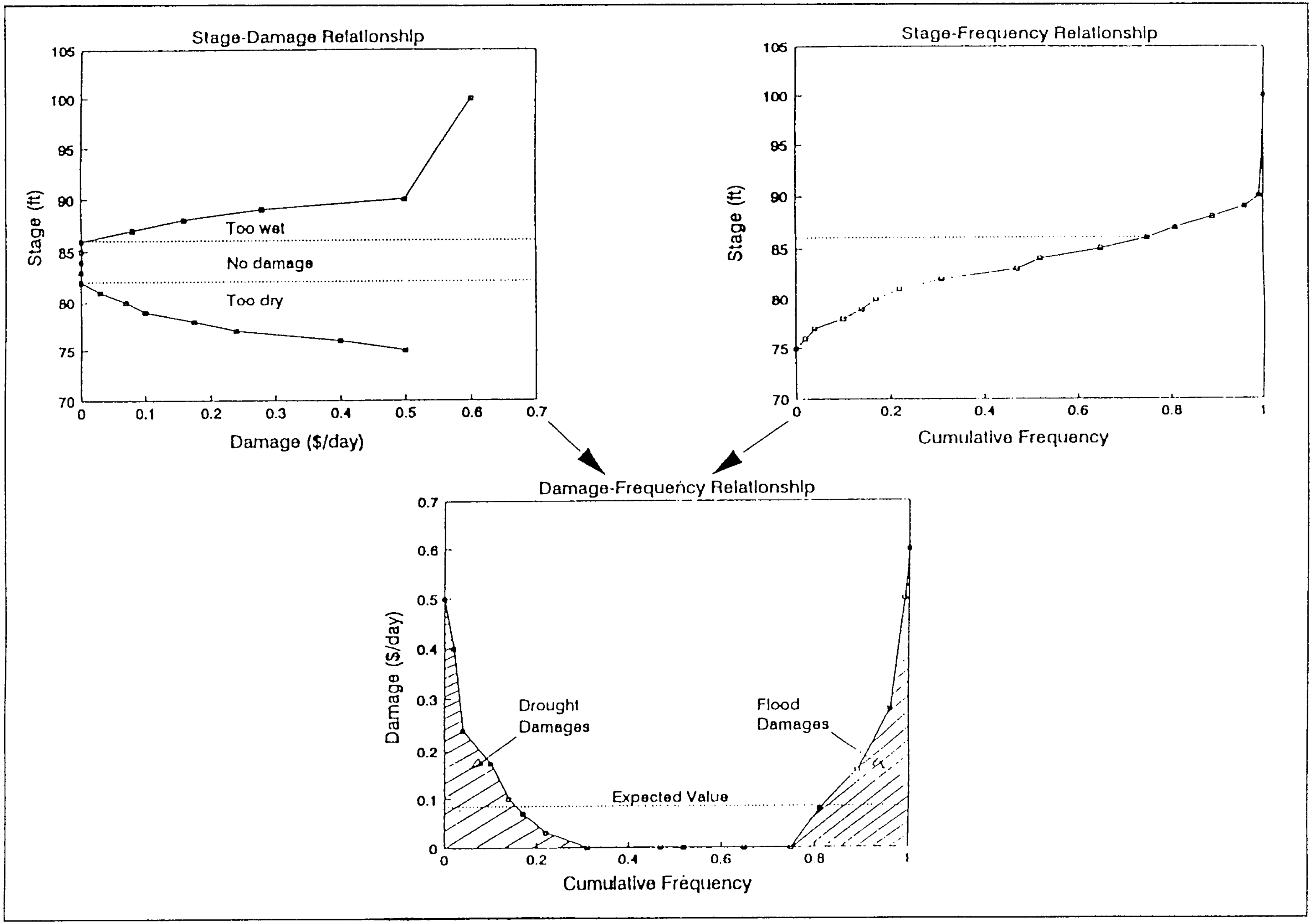


FIGURE 4
DERIVATION OF STAGE -- DAMAGE RELATIONSHIP

TABLE 4
SELECTED LAND SALES DATA FOR DRAINED AND UNMODIFIED WETLANDS IN FLORIDA

No.	County	Sale Date	Water Body	Acres	$/Acre	1990 $/Acre	Crop
1	Lake	Jun-87	L. Griffin	900	3000	3412	Vegetables
2	Lake	Jun-87	L. Griffin	750	3000	3412	Vegetables
3	Lake	Feb-88	L. Apopka	140	3929	4291	Vegetables
4	Lake	Aug-86	L. Apopka	78	4487	5289	Vegetables
5	Lake	Oct-88	L. Apopka	1563	3199	3494	Vegetables
6	Lake	Sep-89	L. Apopka	80	3500	3647	Vegetables
7	Orange	Jul-89	L. Apopka	400	4625	4819	Vegetables
8	Hernando	Nov-84	--	7244	244	303	None
9	Hernando	Apr-84	--	7960	251	312	None
10	W. Palm	Oct-81	L. Okeechobee	1244	3000	4264	Sugar
11	W. Palm	Mar-83	L. Okeechobee	1600	3093	4012	Lettuce
12	W. Palm	Jul-83	L. Okeechobee	2266	2207	2863	Sod
13	W. Palm	Nov-84	L. Okeechobee	1830	3000	3731	Sugar
14	W. Palm	Jun-85	L. Okeechobee	320	2820	3386	Sugar/Veg.
15	W. Palm	Dec-85	L. Okeechobee	46	3025	3632	Sugar
16	W. Palm	Apr-86	L. Okeechobee	360	2500	2947	Sugar
17	W. Palm	Apr-86	L. Okeechobee	2046	2800	3301	Sod
18	W. Palm	Mar-88	L. Okeechobee	300	2600	2840	Sugar
19	W. Palm	Apr-88	L. Okeechobee	326	2436	2660	Sugar

Summary

Lake	n	$/Acre		
		Mean	Minimum	Maximum
Okeechobee	10	3364	2660	4264
Apopka	5	4308	3494	5289
Griffin	2	3412	3412	3412
Undrained	2	308	303	312

Consumer Price Index

Year	Value	Year	Value
81	90.9	82	96.5
83	99.6	84	103.9
85	107.6	86	109.6
87	113.6	88	118.3
89	124.0	90	129.2

LAKE VALUATION

The value of lakes can be determined in the same manner as described above for normal land uses by viewing the lake as a "land use" whose value can be estimated based on its ability to generate income and/or enhance nearby property values. The total economic value of a lake is its value added to nearby property plus its value for other purposes which has not been capitalized in the water-related property values. Khatri-Chhetri and Hite (1990) summarize previous efforts to evaluate the various factors that influence lake waterfront property values. These studies have typically relied on developing regression models based on data for a cross-section of lakes. A major limitation is that no standardized databases are available. Our approach has been to interview county tax assessors and to obtain from them estimates of waterfront property values per front foot and then to combine this information with our lake water quality trophic state index (TSI) and hydrologic information. The TSI is a standard tool used in Florida (Huber et al. 1982, Hand et al. 1990). The results of detailed recreation use studies of five lakes in the Oklawaha chain are shown below:

Activity	Annual $/Acre of Lake
Sport fishing	$100
Beaches	15
Boating	55
Canoeing	9
Total	$179

General criteria for water-based recreation in rivers and lakes are shown below (National Ecology Research Center 1990):

	Depth in Feet	
Activity	Minimum	Maximum
Canoeing-river	0.5	1.5
Water skiing	5	9
Sailing	3	5
Boating-high power	3	4
Swimming	3	4

These constraints can be combined with stage-area relationships for a water body to estimate its overall recreational value, given its water quality.

Adjustments Due to Lake Level Fluctuations

This section describes how values can be adjusted based on the extent of fluctuations in lakes. Two lakes in north Florida were studied as the basis for this method: Lake Brooklyn, which fluctuates over 20 feet, and nearby Lake Santa Fe, which fluctuates 5.5 feet. From the point of view of economic impacts, the most important measure is not the range of elevations but rather the range of surface areas. The effect of the recent drought in Florida on the level of Lake Brooklyn is dramatic as shown in Figure 5. During recent years, the lake has gone from full to 23 percent of its original surface area. This loss of surface area has had a major impact on lakefront property values based on a sample of 67 land sales from February 1981 to January 1991. The estimated sales price for waterfront property on Lake Brooklyn is $240 per front foot. By comparison, the average sales price per front foot for nearby stable Lake Santa Fe is $904 per front foot. Under worst case conditions, Lake Santa Fe is still 96 percent of its original area. Both lakes have excellent water quality.

Adjustments for Water Quality

The Trophic State Index (TSI) has evolved as the accepted single measure of water quality of lakes in Florida (Hand et al. 1990). According to the Florida Department of Environmental Regulation, the TSI for lakes can be placed in the following categories:

	TSI
Range	Lake Quality
0-59	good
60-69	fair
70-100	poor

The TSI's for 573 Florida lakes indicate a range from nearly 0 to over 100 with a median TSI of about 50. The TSI and associated assumed impact on waterfront property values are shown in Table 5. Lakes Brooklyn and Santa Fe both have excellent water quality. However, Lakes Apopka (TSI = 86.8), Griffin (TSI = 76.5), and Harris (63.1) have seriously degraded water quality. The water quality of Lakes Griffin and Harris is affected by Lake Apopka drainage.

The total estimated value per acre of lake area for eight lakes in Florida that accounts for riparian and nonriparian values including the effects of water quality, extent of lake level fluctuations, lake size, and developability of the perimeter are shown in Table 6 (Heaney et al. 1991). The results indicate that lake surface area as a land use generates an annual income of less than $24 per acre for polluted Lake Apopka to nearly $1,000 per acre for high quality Lake Santa Fe. Larger lakes with good water quality and stable lake levels generate higher income values than high value agriculture. These estimates of value are felt to be conservative because they exclude nonuser values. Water supply, flood control, and water quality control were not major purposes for these lakes.

Lake Brooklyn

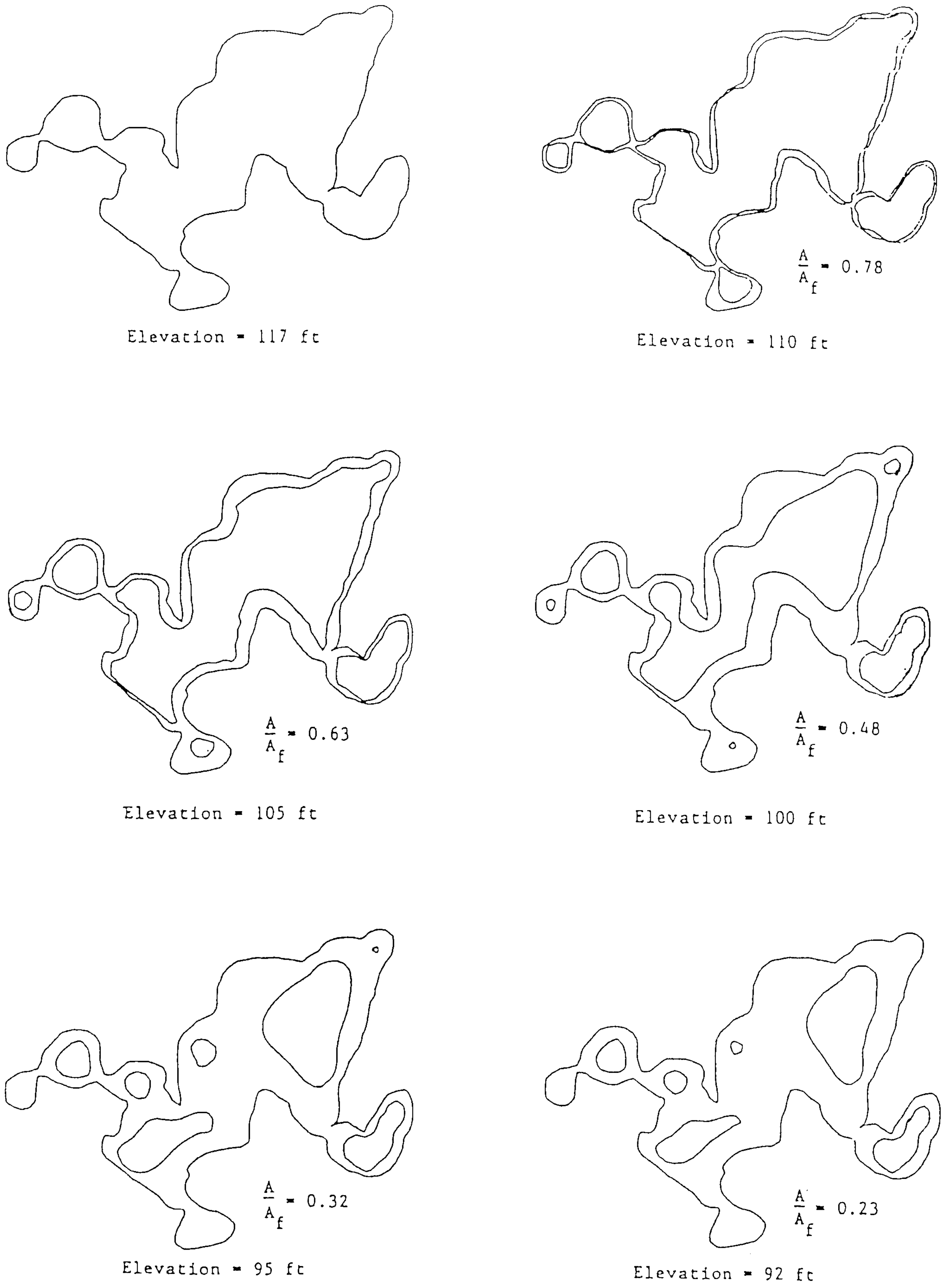


FIGURE 5
CHANGE IN AREA AS LEVEL DECLINES FOR LAKE BROOKLYN

TABLE 5
LAKE DATABASE FOR ESTIMATING THE IMPACT OF TSI ON BENEFITS

Number	Lake	County	Area Acres	TSI
1	Magnolia	Clay	201	21.7
2	Brooklyn	Clay	635	29.0
3	Kingsley	Clay	1,627	29.9
4	Geneva	Clay	1,746	30.6
5	Santa Fe	Alachua	5,299	44.9
6	Yale	Lake	4,930	55.7
7	Orange	Alachua	13,160	58.6
8	Harris	Lake	17,650	63.1
9	Newnans	Alachua	7,350	72.9
10	Griffin	Lake	10,660	76.5
11	Dora	Lake	4,437	81.4
12	Apopka	Lake	30,670	86.8

TABLE 6
ESTIMATE OF VALUES FOR SELECTED CENTRAL FLORIDA LAKES

1	2	3	4	5	6	7	8	9	10	11	12	13	14
					Nonriparian Annual Income		Equivalent Annual Income of Enhanced Property Value						
								Potential Property		Estimated Property			
Lake	Acres	Amin/ Amax	TSI	TSI Factor	Potential $/Acre	Net $/Acre	P/Pcalc.	$/front ft.	$/Acre	$/front ft.	$/Acre	Annualized Property Value, $/Acre	Total Annual Income $/Acre
Yale	4030	0.9	40	0.92	77.30	63.77	0.8	862.00	10050	569	6633	663.32	727.09
Dora	4437	0.9	84	0.30	81.19	21.92	1	887.00	9856	240	2661	266.12	288.04
Eustia	7806	0.9	65	0.66	113.32	66.93	1	966.00	8087	570	4777	477.66	544.59
Griffin	10660	0.9	70	0.56	0.00	0.00	0.8	1000.00	7166	405	2902	290.22	290.22
Harris	17650	0.9	61	0.73	0.00	0.00	1	1000.00	5569	658	3665	366.51	366.51
Apopka	30630	0.9	89	0.21	0.00	0.00	0.3	1000.00	4227	56	235	23.54	23.54
Brooklyn	635	0.23	30	1.00	35.26	8.11	2.	547.03	16061	252	7388	738.81	746.92
Santa Fe	5299	0.96	40	0.92	89.41	78.68	1.1	927.00	9418	897	9117	911.70	990.37

Column	Description
1	Lake name
2	Area when lake is at its normal full elevation
3	Stability factor, STABF, i.e., ratio at minimum stage to A(min) to maximum stage, Amax, or STABF = Amin/Amax
4	Tropic state Index of water quality. (Hand et al. 1990)
5	Water quality factor (WQF) as a function of TSI. (See Table 6.29)

TSI	WQF
< = 30	WQF = 1
30 < TSI < = 60	WQF = 1 - .25 * (TSI - 30)/30
60 < TSI < = 100	WQF = .75 - .75 * (TSI - 60)/40

Column	Description
6	Potential annual income per acre from nonwaterfront users.

Acres	Income, $/Year
< = 100	Inr = 81.95
100 - 1000	Inr = 16 + 32.4 * (A - 100)/900
1000 - 10000	Inr = 48.4 + 85.85 * (A - 1000)/9000
> = 10000	Inr = 134.25

Column	Description
7	Estimated annual income, il = lp * STABF * WQF (See Equation 6.7)
8	Perimeter factor, i.e., ratio of developable lake perimeter (P) to calculated perimeter, P (calc), assuming lake is circular, i.e., PERIMF = P/P(calc)
9	Potential waterfront property value, v. (See Table 6.31)

Area Range Min	Area Range Max	v(max), $/front foot
0	100	v(max) = 3.58 * A
100	1000	v(max) = 358 + 318 * (A-100)/900
1000	5000	v(max) = 676 + 246 * (A-1000)/4000
5000	10000	v(max) = 922 + 78 * (A-5000)/5000
10000	Infinity	v(max) = 1000

Column	Description
10	Potential property value, $/acre, = Vmax = v(max) * (4*43560*pi/A)^.5
11	Estimated property value, $/front foot v = v(max) * WQF * STABF * PERIMF
12	Estimated property value, $/acre V = Vmax * [v/v(max)]
13	Estimated annual income, from riparians, $/acre, Ir = V * i where i = capitalization rate, = .10
14	Total estimated annual income, $/acre, = I = Inr + Ir

WETLAND VALUATION

In the previous section, a lake is considered as a "land use" and values per acre are estimated for lakes of various sizes and of differing water quality. This same approach will be used for wetland valuation.

A large literature exists for valuing wetlands with a very wide range of values. For example, Table 7 lists floodplain natural and cultural values that can be used as a checklist for wetlands (U.S. Water Resources Council 1979). Shabman and Batie (1988) list three key principles that must be followed in establishing values for wetland functions:

1. The services provided by the wetland must be identified and then directly linked to the wetland.

2. The with-and-without principle must be used to estimate benefits.

3. The alternative cost method must represent the least costly way to provide "equivalent" service that would actually be implemented.

Farber and Costanza (1987) and Costanza, Farber and Maxwell (1989) present methods to value wetlands from an ecologist's perspective. The general feeling is that many of the wetland benefits are public and cannot be captured by the property owner. Thus, wetlands are undervalued in the property market.

Analysis of the wetlands land sales database for Florida, presented in Table 4, shows that the market value of wetlands ranges from about $300 per acre for undrained wetlands to over $5,000 per acre for wetlands with sophisticated water control (Heaney et al. 1991). Expected values of drained wetlands in urban areas would be of the order of $30,000 per acre or more. Thus, the economic incentives for wetland drainage are clear. The provision of water management permits a wetland to go from $300 without water control, to $3,000 per acre for agricultural water use, to $30,000 per acre for urban land use.

For the Florida case study, it was fortunate that the St. Johns River Water Management District has an active land acquisition program which has been prioritized based on the following five criteria:

1. Water management benefits;
2. Water supply benefits;
3. Water resource conservation and protection benefits;
4. Need for the project implementation; and
5. Cost to supply identified benefits.

To support this effort, a study was done on the suitability of candidate parcels using the following criteria:

1.	Water quantity	5.Access
2.	Water quality	6.Restorability
3.	Fish/wildlife habitat	7.Manageability
4.	Recreation	8. Availability

The use of the P&G was combined with the database provided by the St. Johns River Water Management District and this author's own concepts to evaluate the wetlands from a functional point of view. The results are presented below. A more detailed summary is contained in Heaney et al. (1991).

Water Supply Benefits

The concept of a water supply function is typically based on the premise that the wetland area serves as a recharge area for the groundwater supply. Additionally, it is necessary to show that, with the loss of this function, an alternative supply would be necessary. For this case study, the water supply benefits of these wetlands are not significant.

Flood Control

In general, wetlands store water during periods of high runoff. This storage has a routing effect on the runoff hydrograph, thereby reducing the magnitude of peak flows. A good example of the ability of wetlands to provide flood control is documented in the U.S. Army Corps of Engineers (1971) study of the Charles River Watershed in Massachusetts. This COE study states that, during an actual recorded flood event, the natural valley storage reduced the flood peak by 65 percent and lagged the peak outflow by about three days. Evaluating the loss of wetlands, the COE calculated the avoided flood damages to be $647,000 per year. A dramatic example of the effect of loss of wetlands and channelization on flood peaks is the Kissimmee River Basin where major wetland drainage occurred (Bedient, Huber, and Heaney 1977). The downstream flood peaks with and without the wetland drainage and channelization, shown in Figure 6, indicates how the flood hydrographs have gone from lower peaks and longer durations (1953-54 and 1960-61) to much higher peaks with shorter durations (1969-70). In this study, the effect of drainage was quantified in terms of drainage density as shown in Figure 7 wherein drainage density is seen to increase several fold as drainage occurs. This provides direct surface pathways for the stormwater and associated pollutants to reach the receiving water.

A detailed flood analysis was done for the Oklawaha Chain with and without wetlands. The results indicate that restoration of the local wetlands would have only minor flood control benefits since the existing flood control system is adequate and downstream development is not significant.

TABLE 7
LIST OF FLOODPLAIN NATURAL AND CULTURAL VALUES

I. Water Resources Values

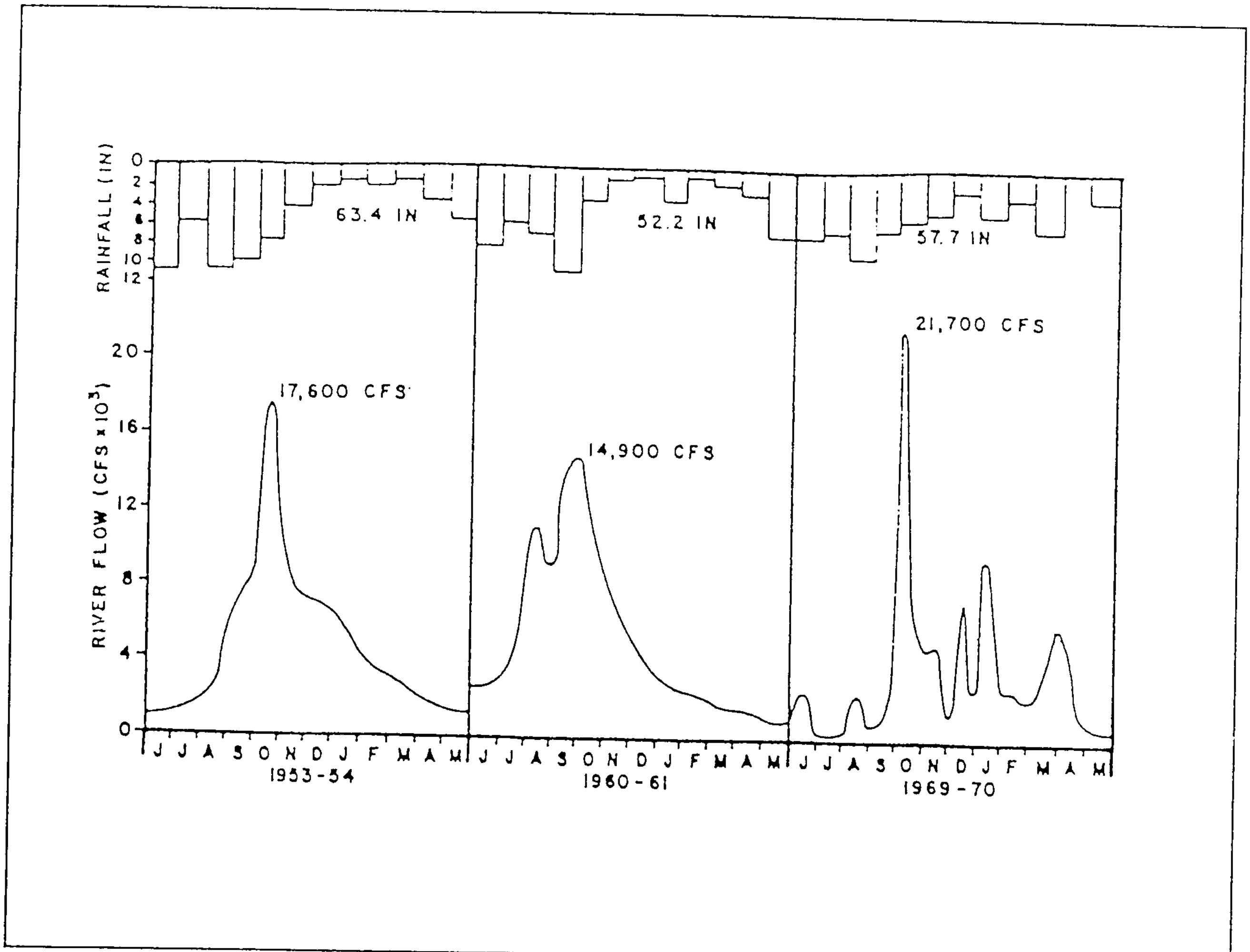
- A. Natural Flood and Erosion Control
  - Reduce flood velocities
  - Reduce flood peaks
  - Reduce wind and wave impacts
  - Stabilize soils
- B. Water Quality Maintenance
  - Reduce sediment loads
  - Filter nutrients and impurities
  - Process organic and chemical wastes
  - Moderate temperature and water
  - Reduce sediment loads
- C. Maintain Groundwater Supply and Balance
  - Promote infiltration and aquifer recharge
  - Reduce frequency and duration of low flows
- D. Water Supply
  - Irrigation
  - Municipal
  - Industrial
  - Energy
- E. Navigation

II. Living Resources Values

- A. Support Flora
  - Maintain high biological productivity of floodplain and w
  - Maintain productivity of natural forests
  - Maintain natural crops
- B. Provide Fish and Wildlife Habitat
  - Maintain breeding and feeding grounds
  - Create and enhance waterfowl habitat
  - Protect habitat of rare and endangered species

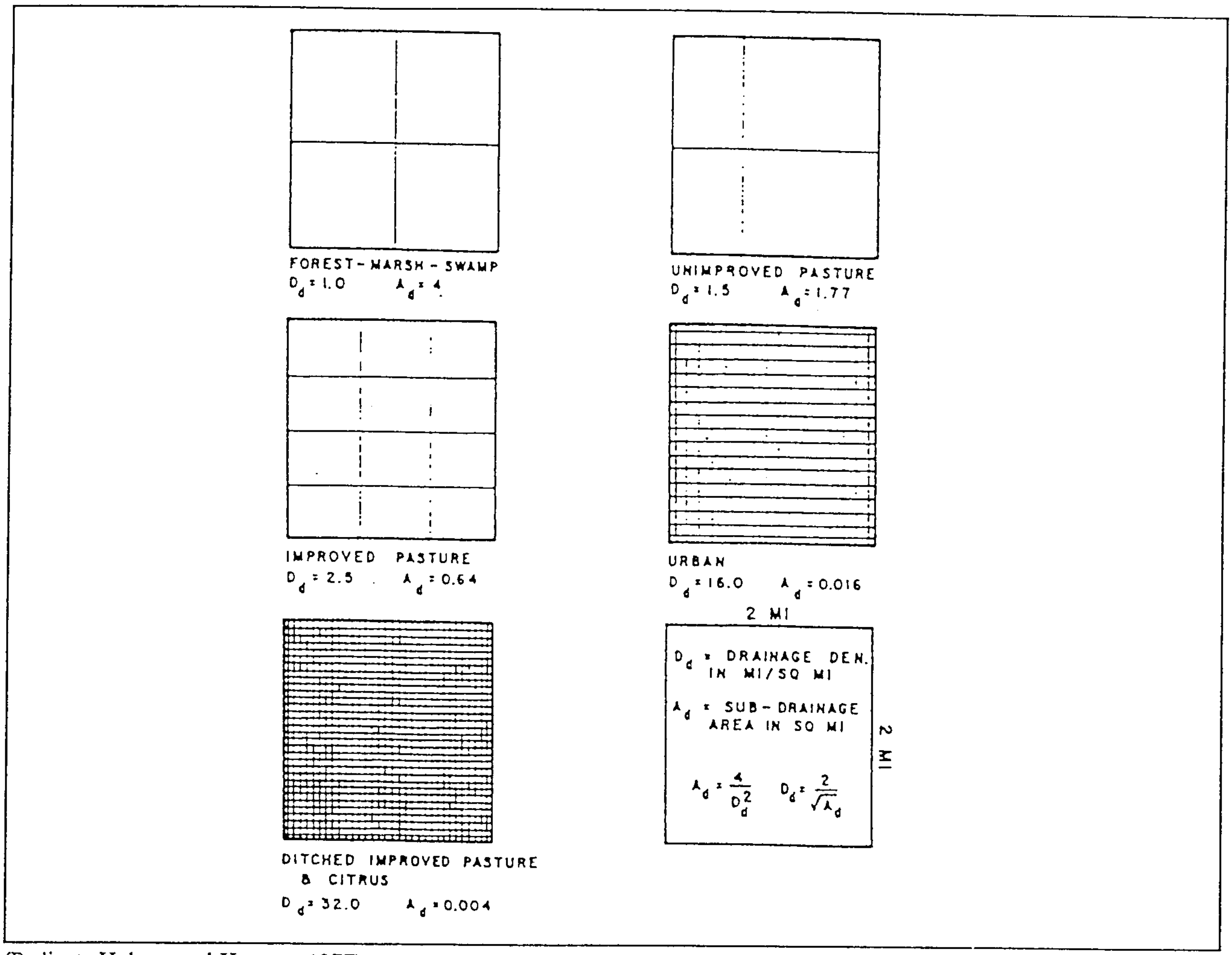
III. Cultural Resource Values

- A. Maintain Harvest of Natural Products
  - Create and enhance agricultural lands
  - Provide areas for cultivation of fish and shellfish
  - Protect silvaculture
- B. Provide Recreation Opportunities
  - Provide areas for active and consumptive uses
  - Provide areas for passive activities
  - Provide open space values
  - Provide aesthetic values
- C. Provide Scientific Study and Outdoor Education Values
  - Provide opportunities for ecological studies
  - Provide historical and archeological sites



(Bedient, Huber, and Heaney, 1977)

FIGURE 6
EFFECT OF CHANNELIZATION AND UPLAND DRAINAGE ON FLOOD HYDROGRAPHS IN THE LOWER KISSIMMEE RIVER BASIN



(Bedient, Huber, and Heaney, 1977)

FIGURE 7
DRAINAGE DENSITY AND LAND USE IN THE KISSIMMEE RIVER BASIN

On-site Stormwater Quality Management

The State of Florida has established regulations for agricultural discharges. The performance standards require that:

1. Discharges from the agricultural stormwater management system shall not cause or contribute to a violation of water quality standards in waters of the state.

2. The stormwater management system shall be designed and operated to provide a level of treatment so that discharges will not contain more than 20 mg/l of biochemical oxygen demand and 20 mg/l of total suspended solids.

3. The stormwater management system shall be designed and operated to provide a level of treatment and pollutant reduction so that pollutant loads discharged to surface waters of the state from a particular agricultural operation are 80 percent less than those from a similar operation which did not incorporate a treatment system or water quality practices.

The prescribed water quality practices are:

1. Wet detention treatment volume is equal to the first inch of runoff.

2. The permanent pool volume provides an average residence time of 21 days during the wet season (June through October). This volume may be determined by estimating 13.82 percent of the wet season average runoff.

3. Pond depths below the water control elevation for new ponds should not exceed an average depth of four feet or a maximum depth of ten feet. Existing ponds should be altered to conform to pond depths not exceeding five feet over 70 percent of the pond area.

For this application, the agricultural simulation model developed by Heaney et al. (1989) can be used to size the detention system. The results of this calculation indicate an annual value of these stormwater quality management systems of $561 per acre with a range from $448 to $674 per acre.

Off-site Wastewater and Stormwater Treatment

The use of wetlands for wastewater treatment is well documented, e.g., Hammer 1989. The alternative cost method is used to value the wetlands for treatment purposes. As of 1991, no requirement existed for general stormwater quality control. Thus, no benefit is claimed for off-site stormwater treatment. The feasibility of wetlands for wastewater treatment depends on their proximity to the waste sources, receiving water quality requirements, and the nature of adjacent land areas. For this study area, the competitive alternative to wetlands is spray irrigation. For those areas where wetlands were favorably located, the estimated annual wetland benefits ranged from $233 per acre to $1,550 per acre with a mean of $893 per acre.

Recreation

In cases of wetlands riparian to the lakes, removal of the dikes causes these wetlands to become part of the lake. Analysis of the stage-area relationships for the affected lakes indicates the type of recreation that can be supported by the wetlands. A reasonable estimate was found to be the sum of sport fishing, canoeing, and one half of the boating values or a total annual recreation value of $1,620 per acre.

Water Management and Navigation

For these purposes, it could only be determined that the impact was positive, but the magnitude could not be estimated.

Summary of Wetland Values

This section has clearly demonstrated that it is possible to derive defensible estimates of wetland values based on their functions. The results for this case study are shown below:

WETLAND FUNCTION	Present Value of Benefit.$/Acre
Water supply	$0
Flood control	5
Water quality	561
Stormwater control	+
Wastewater treatment	893
Recreation	1,620
Watermangement/navigation	+

+Positive benefit is possible, but no value was determined.
*Value for Knight, Lowerie Brown, Eustis and Long Farms only.

These benefits are wetland specific. Also, the benefits are not necessarily additive. For example, a wetland used for wastewater treatment cannot provide the same level of service for recreation. These values represent a lower bound on the value of these wetlands. Nonuser benefits have not been included.

This case study illustrates that it is possible to develop defensible estimates of wetland values using a process oriented functional analysis of the services that they perform. The value of wetlands, as any other land use, can be expected to vary widely depending on the demand for these services. For example, for this case study, the wetlands had relatively little value for flood control storage whereas they have a major impact on flood storage for the nearby Kissimmee River Basin (Bedient, Huber, and Heaney 1977).

APPLICATIONS OF B-C ANALYSIS PRINCIPLES WITHIN FEDERAL AGENCIES

While the general methodology for benefit-cost analysis is well defined, its application by government agencies is sometimes restricted due to their limited missions and legislative mandates. Several illustrative examples developed from review of feasibility reports are presented below:

1. Under the U.S. Army Corps of Engineers 1135 Environmental Restoration program, restoration benefits are prescribed to be defined in terms of fish and wildlife habitat. Recreation benefits are often not included.

2. Benefit-cost analyses for irrigation projects often do not account for the degradation in water quality caused by leaching salts and other constituents such as selenium from the soil, e.g., Kesterson Wildlife Refuge problem (San Joaquin Valley Drainage Program 1990).

3. Flood control projects using levees do not always account for the loss of wetlands, e.g., the review of the 1993 Great Flood (Heaney 1994).

4. Water supply reservoir construction often do not account for the impact of streamflow modification on low flows in the downstream river.

5. Some flood control and drainage projects have not accounted for increased off-site water quality problems, i.e., stormwater pollution, e.g., Lake Apopka muck farms and the Everglades Agricultural Area discussed above.

6. Navigation projects sometimes do not consider all detrimental impacts of flow regulation on other uses of the river, e.g., the current debate on the impact of navigation on the Lower Missouri River system (Heaney 1994).

Thus, a major restructuring of the application of benefit-cost procedures would be needed to require a uniform application of these principles within and across federal water agencies. Interestingly, a recent high level interagency committee report recommends such action (U.S. Advisory Commission on Intergovernmental Relations 1993).

CONCLUSIONS ON ENVIRONMENTAL VALUATION

Benefit-cost analysis methods have been used by the federal government since 1936 and standardized guidelines have existed since 1950. These guidelines have continued to be refined with the latest version appearing in 1983. Also, the Institute of Water Resources of the Corps of Engineers has an active program of developing more detailed guidelines for each of the major functional areas in water resources. In general, there seems to be agreement on the P&G methods for assessing benefits and that suitable models are available.

The P&G, coupled with the mainstream literature on environmental economics, proved to be adequate conceptual guidance for developing a benefit-cost methodology for the St. Johns River Water Management District with emphasis on quantifying environmental benefits. The main gap in assessing environmental impacts is simply that the calculations have not been done even though the methods exist. Thus, existing projects have been justified by a calculus that ignores these significant disbenefits due to environmental degradation. Given that such calculations were omitted, what can be done? One option is to recalculate the benefits using this more complete procedure. This will provide a much more plausible basis for environmental remediation benefits than simply looking at fish and wildlife habitat.

An important reason why environmental benefit quantification seems so imbalanced is that the prescribed procedures vary from program to program even within a given agency. Two key omissions from existing methods that could provide much improved estimates of environmental values are:

1. Inconsistent use of available methods for assessing recreational benefits.

2. Not properly estimating disbenefits resulting from technological externalities caused by water projects even though the methods for doing so are straightforward.

Given the rapidly changing role of the stakeholders in water resources projects, it is important to explicitly quantify the incidence of these benefits. For example, EPA no longer provides direct federal support for controlling combined sewer overflows in urban areas. Thus, local stakeholders, who must pay some or all of the costs, are quite interested in how the benefits are distributed and to explore multipurpose opportunities.

While many papers and books are available on benefit-cost analysis, there is a dearth of good data available on rigorous attempts to quantify these environmental impacts. Some of the blame for this lack of data rests on the shoulders of the economics profession who place higher value on conceptual versus experimental studies. This is unfortunate since the conceptual models are excellent, but the quality of the applications is lacking due to lack of rigorous database development. By contrast, biologists and ecologists who entered the environmental impact field during the past twenty years brought relatively little in the way of a conceptual framework, but they did put major efforts into database development. The result is that the ecologists and biologists have a much better site-specific knowledge of environmental impacts which gives added credibility to their findings.

The fundamental data gaps are most serious for agricultural activities which tend to be of major importance at the river basin scale. For example, if water withdrawals for irrigation are not measured, then the ability to do an accurate assessment of irrigation benefits is quite limited. Thus, it is vital to evaluate the extent to which available data will support the use of various analytical methods. On the cost side, the P&G is not very informative but other federal guidance documents and cost-estimating models are quite helpful. Some vexing issues related to cost allocation remain, but these can be dealt with in later stages of the cost analysis.

The P&G Guidelines (1983) and supporting IWR reports on specific project purposes are conceptually sound and provide good general guidance. In summary, the suggested analytical approach to use is as follows:

1. Estimate benefits by purpose but keep accounts for all affected groups.

2. Place strong emphasis on developing a high quality database so that the estimates are creditable.

3. Develop and calibrate a continuous simulation model to perform this analysis.

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REFERENCES

Bedient, P. B., W. Huber, and J. Heaney. 1977. "Environmental Model of Kissimmee River Basin." Journal of Water Resources Planning and Management Division. Proc. ASCE, 103, WR2.

Boyce, B. N. 1981. Real Estate Appraisal Terminology. 2nd ed., Ballinger, Cambridge, MA.

Costanza, R., S. C. Farber, and R. J. Maxwell. 1989. "Valuation and Management of Wetland Ecosystems." Ecological Economics. 1:335-61.

Farber, S. C. and R. Costanza. 1987. "The Economic Value of Wetlands Systems." Journal of Environmental Management. 24:41-51.

Freeman, A. M. 1979. The Benefits of Environmental Improvement. Johns Hopkins Press, Baltimore, MD.

Greeley-Polhemus Group. 1992. Guidelines for Risk and Uncertainty Analysis in Water Resources Planning, Volumes I and II. IWR Reports 92-R-1 and 92-R-2, Institute for Water Resources, U.S. Army Corps of Engineers, Fort Belvoir, VA.

Hall, G., C. Ware, and G. Bethune. 1988. Draft SWIM Plan for the Upper Oklawaha River. St. Johns River Water Management District, Palatka, FL.

Hammer, D. A. 1989. Constructed Wetlands for Wastewater Treatment; Municipal, Industrial and Agricultural. Lewis Publishers.

Hand, J., V. Tauxe, M. Friedemann, and L. Smith. 1990. 1990 Florida Water Quality Assessment, 305(b). Technical Appendix, Florida Department of Environmental Regulation, Tallahassee, FL.

Heaney, J. P. 1988. "Cost-Effectiveness and Urban Storm-Water Quality Criteria." Proc. Engineering Foundation Conference on Urban Runoff. ASCE, New York, 15 pp.

Heaney, J.P., T.D. Feather, and M. Shafer. 1989. Development of a Socio-Economic Assessment Methodology with Applications to the Lake Apopka Basin. Publication No. 114. Florida Water Resources Research Center, University of Florida, Gainesville, FL.

Heaney, J.P., S. Kenner, C. Cosio, and M. Fowler. 1991. General Methodology for Evaluating the Socio-Economic Impacts Associated with Water Resources Projects. Florida Water Resources Research Center, University of Florida, Gainesville, FL.

Heaney, J.P. 1994. Hydrologic and Water Resources Engineering Aspects of the Great Flood of 1993 in the Upper Mississippi and Lower Missouri River Basins. Final Report to the Scientific Assessment and Strategy Team, USGS EROS Data Center, Sioux Falls, SD.

Huber, W.C. 1982. A Classification of Florida Lakes. Florida Water Resources Research Center Report 72, University of Florida, Gainesville, FL.

Hufschmidt, M.M., D.E. James, A.D. Meister, B.T. Bower, and J.A. Dixon. 1983. Environment, Natural Systems, and Development: An Economic Guide. Johns Hopkins Press, Baltimore, MD.

Interagency Floodplain Management Task Force. 1994. Sharing the Challenge: Floodplain Management into the 21st Century. Washington, DC.

Khatri-Chhetri, J.B. and J.C. Hite. 1990. "Impact of Reservoir Levels on the Market Value of Lakeshore Properties." *Rivers*, 1(2):138-47.

Kneese, A.V. and B.T. Bower. 1979. Environmental Quality and Residuals Management. Johns Hopkins Press for Resources for the Future, Baltimore, MD.

Ortolano, L. 1984. Environmental Planning and Decision Making. John Wiley, NY.

San Joaquin Valley Drainage Program. 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. Final Report, Sacramento, CA.

Schmid, A.A. 1989. Benefit-Cost Analysis. Westview Press, Boulder, CO.

Shabman, L.A. and S.S. Batie. 1989. Socioeconomic Values of Wetlands: Literature Review, 1970-1985. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Smith, V.K. 1986. "A Conceptual Overview of the Foundations of Benefit-Cost Analysis, in Bentkover, et al." Benefits Assessment. Reidel, pp. 13-34.

Tobin, G. and T. Newton. 1986. "A Theoretical Framework of Flood Induced Changes in Urban Land Values." Water Resources Bulletin. 22:67-71.

U.S. Advisory Commission on Intergovernmental Relations. 1993. High Performance Public Works—A New Federal Infrastructure Investment Strategy for America. U.S. Army Corps of Engineers, Ft. Belvoir, VA.

U.S. Army Corps of Engineers. 1971. Charles River Massachusetts, Water Resources Development Plan, Charles River Watershed, Massachusetts, Appendix D—Hydrology and Hydraulics, Appendix H—Flood Management - Plan Formulation. Department of the Army, New England Division, Corps of Engineers, Waltham, MA.

U.S. Army Corps of Engineers. 1992. Valuation of Lake Resources through Hedonic Pricing. IWR 92-R-8, Ft. Belvoir, VA.

U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Washington, DC.

Vearil, J. 1991. Water Control Manual for Oklawaha River Basin, Four River Basins Project. Florida Water Resources Research Center Report No. 115, University of Florida, Gainesville, FL.